

What is claimed is:

1 1. A method of forming an image sensor device, comprising
2 the steps of:
3 forming an image sensing array in a substrate, wherein the
4 image sensing array comprises a plurality of
5 photosensors with spaces therebetween;
6 forming a first dielectric layer overlying the spaces but
7 not the photosensors;
8 forming a conformal second dielectric layer on a sidewall
9 of the first dielectric layer, wherein the second
10 dielectric layer has a second refractive index; and
11 forming a third dielectric layer overlying the photosensors
12 but not the spaces, wherein the third dielectric layer
13 has a third refractive index;
14 wherein the third refractive index is greater than the
15 second refractive index.

1 2. The method according to claim 1, wherein the
2 photosensors are photodiodes.

1 3. The method according to claim 2, wherein the
2 photodiodes comprise n-type regions in p-type regions.

1 4. The method according to claim 1, wherein the method
2 of forming the first dielectric layer, the second dielectric
3 layer and the third dielectric layer comprises the steps of:
4 forming the first dielectric layer overlying the
5 photosensors and the spaces;
6 patterning the first dielectric layer by removing part of
7 the first dielectric layer to form an opening above

8 each photosensor while maintaining the first
9 dielectric layer overlying the spaces;
10 forming a dielectric layer on the first dielectric layer
11 and an inner surface of the opening;
12 anisotropically etched back part of the dielectric layer
13 to form the second dielectric layer on the sidewall
14 of the opening;
15 forming the third dielectric layer overlying the first
16 dielectric layer, the second dielectric layer and
17 the opening; and
18 removing part of the third dielectric layer to the first
19 dielectric layer while maintaining the third
20 dielectric layer in the opening.

1 5. The method according to claim 4, wherein the step of
2 patterning the first dielectric layer uses the same reticle that
3 is used for defining ion implantation regions for the
4 photosensors.

1 6. The method according to claim 4, further comprising
2 the step of:
3 performing a planarization to make the top surfaces of the
4 first dielectric layer, the second dielectric layer
5 and the third dielectric layer are coplanar.

1 7. The method according to claim 6, wherein the
2 planarization comprises chemical mechanical polishing.

1 8. The method according to claim 1, wherein the first
2 dielectric layer comprises at least one interlevel dielectric
3 (ILD) layer.

1 9. The method according to claim 8, wherein the first
2 dielectric layer further comprises at least one intermetal
3 dielectric (IMD) layer.

1 10. The method according to claim 9, wherein the IMD layer
2 has multiple dielectric films.

1 11. The method according to claim 10, wherein the multiple
2 dielectric films comprise SiON, SiN and FSG (Fluorinated Silica
3 Glass) films.

1 12. The method according to claim 11, wherein the second
2 dielectric layer is a low-k dielectric layer.

1 13. The method according to claim 12, wherein the low-k
2 dielectric layer is a FLARE, SiLK, FLAC (fluorinated amorphous
3 silicon), fluoro polymer or porous silica layer.

1 14. The method according to claim 13, wherein the third
2 dielectric layer is a TEOS-SiO₂ layer formed by PECVD.

1 15. The method according to claim 1, wherein the third
2 refractive index is greater than the second refractive index
3 by at least about 0.1.

1 16. A method of forming an image sensor device, comprising
2 the steps of:

3 forming an image sensing array in a substrate, wherein the
4 image sensing array comprises a plurality of
5 photosensors with spaces therebetween;
6 forming a first dielectric layer of a multi-dielectric
7 structure overlying the photosensors and the spaces;

8 patterning the first dielectric layer by removing part of
9 the first dielectric layer to form an opening above
10 each photosensor while maintaining the first
11 dielectric layer overlying the spaces;
12 forming a dielectric layer on the first dielectric layer
13 and an inner surface of the opening;
14 anisotropically etched back part of the dielectric layer
15 to form a conformal second dielectric layer on the
16 sidewall of the opening, wherein the second
17 dielectric layer has a second refractive index;
18 forming a third dielectric layer overlying the first
19 dielectric layer, the second dielectric layer and
20 the opening, wherein the third dielectric layer has
21 a third refractive index; and
22 removing part of the third dielectric layer to the first
23 dielectric layer while maintaining the third
24 dielectric layer in the opening;
25 wherein the third refractive index is greater than the
26 second refractive index;

27 wherein a light guide comprising the second dielectric layer
28 and the third dielectric layer is formed overlying each
29 photosensor, thereby preventing incident light from striking
30 other photosensors.

1 17. The method according to claim 16, wherein the
2 photosensors are photodiodes.

1 18. The method according to claim 17, wherein the
2 photodiodes comprise n-type regions in p-type regions.

1 19. The method according to claim 16, wherein the step
2 of patterning the first dielectric layer uses the same reticle
3 that is used for defining ion implantation regions for the
4 photosensors.

1 20. The method according to claim 16, further comprising
2 the step of:

3 performing planarization to make the top surfaces of the
4 first dielectric layer, the second dielectric layer,
5 and the third dielectric layer coplanar.

1 21. The method according to claim 20, wherein the
2 planarization comprises chemical mechanical polishing.

1 22. The method according to claim 16, wherein the
2 multi-dielectric structure comprises SiON, SiN and FSG
3 (Fluorinated Silica Glass) films.

1 23. The method according to claim 22, wherein the second
2 dielectric layer is a low-k dielectric layer.

1 24. The method according to claim 23, wherein the low-k
2 dielectric layer is a FLARE, SiLK, FLAC (fluorinated amorphous
3 silicon), fluoro polymer or porous silica layer.

1 25. The method according to claim 24, wherein the third
2 dielectric layer is a TEOS-SiO₂ layer formed by PECVD.

1 26. The method according to claim 16, wherein the third
2 refractive index is greater than the second refractive index
3 by at least about 0.1.

1 27. The method according to claim 16, wherein a thickness
2 of the second dielectric layer is 200~2000Å.

1 28. An image sensor device, comprising:
2 an image sensing array in a substrate, wherein the image
3 sensing array comprises a plurality of photosensors
4 with spaces therebetween;
5 a first dielectric layer overlying the spaces but not the
6 photosensors;
7 a conformal second dielectric layer on a sidewall of the
8 first dielectric layer, wherein the second dielectric
9 layer has a second refractive index; and
10 a third dielectric layer overlying the photosensors but
11 not the spaces, wherein the third dielectric layer
12 has a third refractive index;

13 wherein the third refractive index is greater than the
14 second refractive index.

1 29. The device according to claim 28, wherein the
2 photosensors are photodiodes.

1 30. The device according to claim 29, wherein the
2 photodiodes comprise n-type regions in p-type regions.

1 31. The device according to claim 28, wherein top surfaces
2 of the first dielectric layer, the second dielectric layer and
3 the third dielectric layer are coplanar.

1 32. The device according to claim 28, wherein the first
2 dielectric layer comprises at least one interlevel dielectric
3 (ILD) layer.

1 33. The device according to claim 32, wherein the ILD layer
2 is a silicon oxide or BPSG (borophosphosilicate glass) layer.

1 34. The device according to claim 32, wherein the first
2 dielectric layer further comprises at least one intermetal
3 dielectric (IMD) layer.

1 35. The device according to claim 34, wherein the IMD layer
2 has multiple dielectric films.

1 36. The device according to claim 35, wherein the multiple
2 dielectric films comprise SiON, SiN and FSG (Fluorinated Silica
3 Glass) films.

1 37. The device according to claim 36, wherein the second
2 dielectric layer is a low-k dielectric layer.

1 38. The device according to claim 37, wherein the low-k
2 dielectric layer is a FLARE, SiLK, FLAC (fluorinated amorphous
3 silicon), fluoro polymer or porous silica layer.

1 39. The device according to claim 38, wherein the third
2 dielectric layer is a TEOS-SiO₂ layer formed by PECVD.

1 40. The device according to claim 28, wherein the third
2 refractive index is greater than the second refractive index
3 by at least about 0.1.

1 41. The device according to claim 28, wherein a thickness
2 of the second dielectric layer is 200-2000Å.